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WATER SUPPLY AND WATER QUALITY CONTROL STUDY, BIG BLUE RIVER BASIN, NEBRASKA AND KANSAS

Public Health Service
Kansas City, Missouri

May 1965

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WATER SUPPLY AND WATER QUALITY CONTROL STUDY BIG BLUE RIVER BASIN NEBRASKA AND KANSAS

Study of the Needs and Value of Storage for Municipal and Industrial Water Supply and Water Quality Control

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U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
Public Health Service
Region VI
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(no LC number)

WATER SUPPLY AND WATER QUALITY CONTROL STUDY

BIG BLUE RIVER BASIN
(Nebraska & Kansas)

A study has been made which discloses no present or future need (to the year 2070) for storage in reservoirs for municipal and industrial water supplies. Storage is needed, however, for present and future needs for water quality control. These conclusions are based on analysis of existing water quality information and hydrologic, economic and demographic analyses. Future needs are based on projected population and industrial growth.

Prepared for

DEPARTMENT OF THE ARMY

U. S. Army Engineer District

Kansas City, Missouri

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region VI
Kansas City, Missouri
May, 1965

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2	Typical Chemical Analyses of Public Water Supplies
3	Basic Data on Sources of Pollution
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I. INTRODUCTION

Request and Authority

In a letter dated August 13, 1963, the Kansas City District of the Corps of Engineers requested that the Public Health Service make an investigation to "determine present and prospective needs for water for municipal and industrial uses, and for water quality control in the Big Blue River Basin in Kansas and Nebraska."

This study has been made in accordance with the Memorandum of Agreement dated November 4, 1958, between the Department of the Army and the Department of Health, Education and Welfare, relative to the Water Supply Act of 1958 as amended (43 U.S.C. 3906) (Title III of Public Law 85-500) and the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et seq).

Purpose and Scope

The purpose of this study is to determine the need for and value of storage of municipal and industrial water supply and the need for and value of storage for streamflow regulation for water quality control in the Big Blue River Basin in southeastern Nebraska and northeastern Kansas.

The basin has an area of approximately 9,600 square miles and includes all or parts of Polk, Butler, Seward, York, Hamilton, Kearney, Nuckolls, Thayer, Adams, Clay, Fillmore, Saline, Pawnee, Gage, Webster, Franklin, and Jefferson Counties in Nebraska and Republic, Washington, Marshall, Nemaha, Clay, Riley and Pottawatomie Counties in Kansas.

This study covers the 100-year study period, 1970 to 2070, as requested by the Corps of Engineers.

Acknowledgments

The cooperation of many persons and agencies is gratefully acknowledged. Special appreciation is expressed to the following:

1. Kansas State Department of Health, Topeka, Kansas
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3. Kansas Water Resources Board, Topeka, Kansas
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5. Department of Water Resources, Lincoln, Nebraska
6. Nebraska Department of Health, Lincoln, Nebraska
7. Conservation and Survey Division, University of Nebraska, Lincoln
8. U. S. Geological Survey, Ground Water Branch, Lawrence, Kansas and Lincoln, Nebraska
9. U. S. Geological Survey, Surface Water Branch, Topeka, Kansas and Lincoln, Nebraska
10. U. S. Geological Survey, Water Quality Branch, Topeka, Kansas and Lincoln, Nebraska

II. SUMMARY OF FINDINGS AND CONCLUSIONS

Summary of Findings

1. The Corps of Engineers is making a study of the Big Blue River Basin in Nebraska and Kansas to determine the feasibility of constructing multipurpose reservoirs. Several tentative sites are located on Turkey, Lincoln and Beaver Creeks and on the West Fork and the North Branch of the Big Blue River. These sites are shown on Figure X-1, following Page X-2.

2. The study area includes all or parts of 24 counties in the Big Blue River Basin of Nebraska and Kansas.

3. The 1960 population of the study area was 243,773, of which 85,870 were urban and 157,903 were rural.

Major municipalities in the basin include the following (1960 population shown in parenthesis): Beatrice (14,317), Crete (3,546), Fairbury (5,572), Hastings (21,412), Seward (4,208) and York (6,173) in Nebraska, and Manhattan (22,993) and Marysville (4,143) in Kansas.

4. Waste discharge from the major municipalities are as follows: Beatrice (3,670), Crete (600), Fairbury (4,000), Hastings (6,600), Seward (400), and York (4,000) in Nebraska and Manhattan (discharge to Kansas River) and Marysville (2,900) in Kansas.

Secondary treatment is employed at the towns listed with the exception of Marysville, Kansas, Fairbury and York, Nebraska which have primary treatment.

5. Municipal water use in the basin totaled 21.2 mgd in 1963 with an average daily per capita use of 158 gallons. Industrial

pumpage not reflected in the municipal use is 3.3 mgd and is used primarily for cooling purpose.

6. The quality of surface and ground water in the basin is generally good, although the water is rather hard. The presence of high nitrates in some of the water supplies should be of concern to the towns involved.

Conclusions

1. The population of the economic study area is projected to reach 272,000 in 2020 and 340,000 in 2070.

2. Municipal and industrial water use in the basin is expected to increase to an average of about 36 mgd in 2020 and 56 mgd in 2070. It is anticipated that existing sources of supply will be adequate to serve future demands.

3. With the provision of adequate waste treatment (85% reduction of BOD for the purposes of this report) a summer flow of 16 mgd is required at Hastings and 12 mgd at York to assimilate present waste loadings. This exceeds the present dependable flows at these two locations.

At Crete and Beatrice, Nebraska the Big Blue River is also expected to receive a large waste load due to the expected increases in population; but with adequate treatment, the loads are not expected to exceed the assimilation capacity of the stream.

4. There is a present need for flow regulation for water quality control at Hastings and York, Nebraska.

At Hastings the need at present is 16 mgd in the summer, 11 mgd

in the spring and fall and 7 mgd in the winter. At York the need is 12.1 mgd in the summer, 4.4 mgd in the spring and fall and 1.3 mgd in the winter. An annual draft on storage of 7,750 acre feet will be needed at York and 35,000 acre feet at Hastings by the year 2070.

5. As Hastings is on the extreme headwater of the West Fork of the Big Blue River, the need for regulation for water quality control cannot be supplied from the tentative reservoirs.

6. Water quality control management by the proposed reservoir above York will provide benefits from recreational use of approximately 270 miles of stream from the damsite to Tuttle Creek Reservoir. It is estimated that with streamflow regulation the stream will support 150,000 fisherman-days annually by 1970 increasing to 250,000 fisherman-days by 2070. These estimates should be revised when additional information becomes available. Other recreational uses to be protected are swimming, water skiing and boating. Assured water quality will provide a safe public health environment with the absence of noxious odor, floating solids and excessive turbidity.

7. The minimum value of benefits assignable to storage for water quality control at York is based on the alternative method most likely to be used in the absence of the project, in this case a single-purpose reservoir. The annual value based on a capital cost of $5,500,000 amortized over a one-hundred year period at a rate of 3 1/8 percent and including $10,000 per year operation and maintenance, is $190,400. Since there is an immediate need, benefits have not been discounted.

8. These needs and the value of benefits are based upon the best estimates that can be made at this time but are subject to review and

revision when additional information and data from the Missouri River Comprehensive Study by the U. S. Public Health Service becomes available.

III. PROJECT DESCRIPTION

The Corps of Engineers is making a study of the Big Blue River Basin to determine the feasibility of constructing multipurpose reservoirs for flood protection, recreation and possible flow regulation. Several tentative sites, designated A, D, H, Q, V, and X, are located on Turkey, Lincoln and Beaver Creeks, and on the North Branch and the West Fork of the Big Blue River.

The Bureau of Reclamation is also considering the feasibility of developing sites in the upper portion of the basin at Shestak, Beaver Crossing, Surprise, and Seward View. These sites would be for irrigation and water supply and water quality control as needed. The Bureau of Reclamation's Surprise site is the same as the Corps of Engineers' Damsite "A" and the Bureau of Reclamation's Seward View site is the same as the Corps of Engineers' Damsite "D". The proposed Bureau of Reclamation's Angus damsite is located on the Little Blue River in the western portion of the basin. (Proposed projects are shown on Figure X-1.)

IV. STUDY AREA DESCRIPTION

Location and Boundaries

The Big Blue River Basin which is a part of the Kansas River Basin is between the Republican River Basin on the southwest and the Missouri River on the northeast. The northwest portion of the basin is bordered by the Platte River Basin. The total drainage area of the basin is approximately 9,600 square miles of which 2,384 square miles are in Kansas and 7,216 square miles in Nebraska. The basin is approximately 150 miles long and 100 miles wide at the widest point (see location map).

Geography and Topography

Land elevations in the Big Blue River Basin range from approximately 2,150 feet above mean sea level in the western portion of the basin near Minden to slightly less than 1,000 feet above mean sea level at the junction of the Big Blue River with the Kansas River near Manhattan.

The northern and western portions of the river basin are characterized by gently rolling upland plains of low relief dissected by small meandering streams in shallow valleys. The southern and eastern portions of the basin lie in the central lowlands where the streams have deeply dissected the rocks and the valleys are deeper and more narrow.

Climate

The climate in the Big Blue River Basin is characterized by hot summers and moderately cold winters. At Manhattan, in the southern part of basin,

the January mean temperature is 29.0° F and the July mean temperature is 79.8° F for a 55 year record and extremes range from a low of -32° F to a high of 116° F. The precipitation records at Manhattan show a mean of 31.73 inches and a range of a high of 60.38 inches in 1951 to a low of 19.38 inches in 1934. The mean annual precipitation at Aurora, Nebraska, in northwest part of basin is 26.22 inches.

The frost free growing season in the basin ranges from about 160 to 175 days.

Principal Communities

Within the boundaries of the Big Blue River Basin, there are 15 communities having populations exceeding 1,500 according to the 1960 census. These include Aurora (2,576), Beatrice (12,132), Crete (3,546), David City (2,304), Fairbury (5,572), Geneva (2,352), Hastings (21,412), Hebron (1,920), Minden (2,383), Seward (4,208), Wymore (1,975) and York (6,173) in Nebraska and Marysville (4,212), Washington (1,581) and Manhattan (22,993) in Kansas.

V. WATER RESOURCES OF THE STUDY AREA

Surface Water

Streamflows in the Big Blue River and its tributaries are extremely variable. The Table of Historical Streamflows (Appendix, Exhibit No. 4) shows that the flow at Randolph, Kansas, has ranged from 98,000 cfs down to 31 cfs over 42 years of record. This station, measuring drainage from an area of 9,100 square miles, was at the Tuttle Creek Reservoir site and was discontinued in 1960.

Data on streamflow on the Little Blue River near Barnes, Kansas, show a range of 38,800 cfs maximum to 76.0 cfs minimum. This station measures drainage from an area of 3,330 square miles.

At only eight of the stations have streamflow minimums of less than 25 cfs been recorded and at only three of these have periods of no flow been recorded. Stations recording periods of no flow measure flows from drainage areas of 176 square miles, 225 square miles and 412 square miles.

The dependable uncontrolled annual mean streamflow at four locations in the Big Blue River Basin are shown in Figure V-1. The figure indicates, for example, that a flow equal to or greater than 433 cfs will be available 90 percent of the time at Randolph, Kansas.

The distribution of flow from month to month is more significant for water supply and quality control purposes than differences from year to year. A distribution of median monthly flows, based on the average of five stations in the Big Blue Basin is as follows:

Table V-1

Distribution of Monthly Streamflow

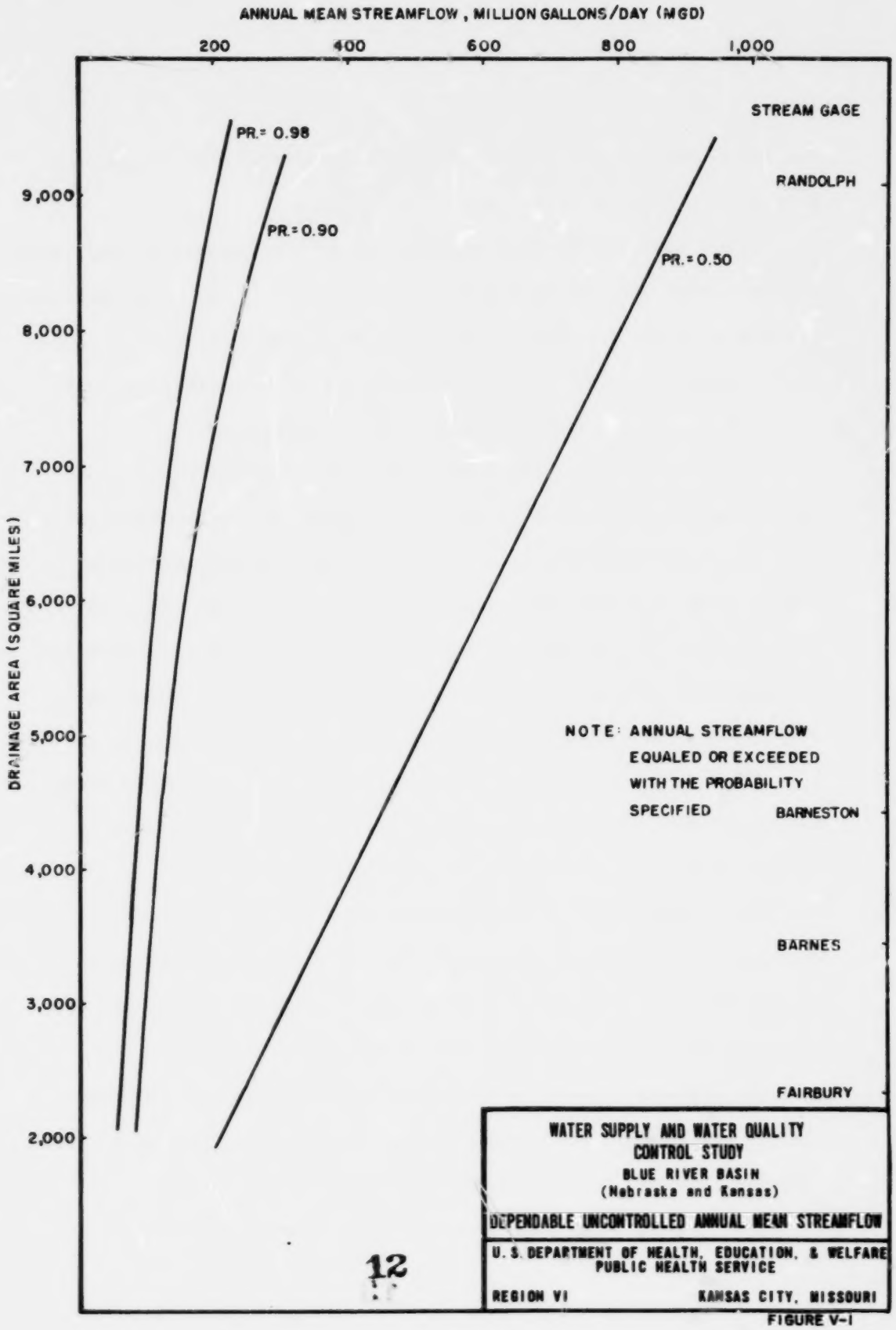
Month	Percent of Annual Flow
April	8
May	10
June	19
July	16
August	8
September	7
October	4
November	4
December	4
January	4
February	6
March	10

As can be seen here, near to or greater than average flows can be expected during the period May-September when water requirements are greatest.

The Big Blue River and its tributaries are mostly effluent in nature and the base flow is supplied by ground water.

Ground Water

Ground water is developed extensively throughout the Big Blue River Basin for municipal domestic, industrial and irrigation uses. Only one town in the basin, Marysville, Kansas draws its supply from surface water and this supply is augmented by ground water. A small



WATER SUPPLY AND WATER QUALITY CONTROL STUDY
BLUE RIVER BASIN
(Nebraska and Kansas)

DEPENDABLE UNCONTROLLED ANNUAL MEAN STREAMFLOW

U. S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE

REGION VI KANSAS CITY, MISSOURI

FIGURE V-1

percent of surface water is also used for industrial and irrigation purposes.

Ground water is found in abundance in sand and gravel of Pleistocene age in a large part of the Big Blue River Basin. In the portions of the basin east of the Big Blue River and in the southern portions of the basin, ground water supplies are found in lesser quantities in glacial till and in sand and gravel along the major watercourses.

Studies 19/ made in the Nebraska portion of the basin indicate an average annual recharge of about 0.7 inches. In these same studies an electric analog computer calculation was made to estimate water levels change and base flow depletions in the basin. The computer was programmed to include a uniform increase in irrigation consumptive use pumpage of 50% over the 1962 level by 1982 from which time the pumping rates were uniformly decreased back to the 1962 level by the year 2022. After 1982 it was anticipated that the lower ground water levels would result in decreased saturated thicknesses resulting in smaller well capacities and higher production costs.

The withdrawal of ground water was predicted to result in a decrease in base flow of the Big Blue River of 9.6 cfs at Barneston by 2022 which is 1.2% of the average annual discharge and 5.0 cfs at Fairbury, which is 1.4% of the average annual discharge.

The assumptions made in this study probably represent the most extreme conditions. The hydraulic gradients into the basin will increase, inducing more inflow from the Platte River while the increased pumping costs resulting from the declining water levels

will be a major role in stabilizing irrigation water use.

The municipal and industrial ground water supplies would be affected to an extent partially depending upon their proximity to irrigation areas. Even with the severe assumptions made in this study, it is not anticipated that municipal supplies will be adversely affected.

Little is known of the recharge conditions and quantity of water in storage in the Kansas portion of the basin. Future demands for irrigation water from ground water sources are not expected to be widespread enough to conflict with municipal supplies. 8/

Municipal pumpage in the Big Blue Basin totaled approximately 21.2 mgd in 1962 or 7,740 million gallons for the year. Pumpage for industrial uses not reflected in municipal use was approximately 3.3 mgd or 1,200 million gallons per year.

Quality of Water

The maximum and minimum concentrations of several chemical constituents of surface water of the Big Blue River Basin are as follows:

Table V-2

Maximum & Minimum Concentrations (mg/l) of Selected Chemical Constituents, Big Blue River Basin

Station	Big Blue River @ Manhattan, Ks.[8] Max	Min	Big Blue River Near Crete, Nebr.* Max	Min	Little Blue River Near Deweese, Nebr.** Max	Min
Dissolved Solids	414	82	314	80	286	71
Hardness	238	52	252	21	193	24
Chloride	47	0	11	0	9.5	0
Sulfate	50	4	47	6.8	34	3.8

* From 21 analyses, flow ranging from 106 to 21,500 cfs

** From 95 analyses, flow ranging from 26.7 to 10,960 cfs

The chemical characteristics of the ground water in the basin above Crete approximates that of the surface water at low flow as the ground water supplies the base flow of the stream. In a few instances iron, manganese, and nitrate concentration are above the limits (not to be exceeded) as stated in the 1962 Public Health Service Drinking Water Standards.[17]

In the area of the basin below Crete near the Big Blue River, ground water supplies are generally more highly mineralized and exceed the upper limits (not to be exceeded) for sulfate, nitrates and total dissolved solids of the 1962 U.S. Public Health Service Drinking Water Standards in several instances.

VI. ECONOMY

An assessment of future municipal and industrial, and quality control water requirements in the Big Blue River Basin involves an appraisal of the area's industrial and population growth potential. The future demand for goods and services from the projected growth of the nation could create an opportunity to the basin for attracting new industries or expand existing ones.

The economic and population projections were the basis for determining future water requirements for municipal and industrial and quality control purposes.

The study area was defined as the counties of Marshall, Riley, and Washington in Kansas, and Adams, Butler, Clay, Fillmore, Gage, Hamilton, Jefferson, Kearney, Nuckolls, Polk, Saline, Seward, Thayer, and York in Nebraska.

Present

General

Agriculture and its related activities have had the most significant effect on the basin's economy in terms of employment. In 1960, 25,212 persons or slightly over 26 percent of the labor force was employed on the farm. Seven percent of the labor force was employed in manufacturing, while less than one percent was employed in the mining category. The dependent industries listed under the services (including construction, transportation, communications, utilities, retail and wholesale trade, public administration and personal services) employed the largest portion with 60,794 or about 64 percent of the total labor force. 1/ See Table VI-1 for employment data.

Agriculture

Agriculture has been the principal basic economic activity in the study area.

Agricultural employment in the study area has declined from 35,948 in 1950 to 25,212 in 1960. [1/] Despite the decrease in the farm employment, agricultural production has increased, when measured by dollar returns. The value of agricultural production increased from 178.5 million dollars in 1954 to 265.2 million dollars in 1959 (adjusted to the 1958 value of the dollar).[2/] Farm consolidation, intensified crop production and increased farm technology were primarily responsible for the increasing farm income and decreasing farm employment.

According to the 1959 Census of Agriculture, there were approximately 700 thousand acres of land irrigated in the study area. The major portion of this irrigation takes place in the northwestern part of the study area. [3/]

Mining

Mineral production in the study area is limited to the extraction of sand and gravel and petroleum. Sand and gravel used mainly for construction purposes locally contributes about 1.5 million dollars annually while the extraction of petroleum contributes about one hundred thousand dollars annually. [4/]

Employment in this category is a minor proportion of total employment ranging from 226 in 1950 to 166 in 1960. [1/]

Manufacturing

Manufacturing employment in the study area comprises only seven

percent of the total labor force. However, since 1950 this employment increased from 5,370 to 6,286 in 1960. 1/

In 1960, food and kindred products and fabricated materials (including vehicles, machinery, transportation equipment and other durables) employed over 60 percent of the manufacturing employment. All other categories were relatively insignificant. See Table VI-3.

Population

The total population of the study area decreased about 15 percent from 287,137 in 1910 to 243,773 in 1960. The urban sector during this period increased from 41,188 to 85,870, while the rural sector decreased from 245,949 to 157,903. 5/

Lack of employment opportunities in the predominant rural economy was primarily responsible for the emigration of the population to larger urban areas in and out of the study area.

The two major cities in the study area (Manhattan, Kansas and Hastings, Nebraska) have shown vigorous growth from 1910 to 1960. Manhattan, with the Kansas State University (with enrollment of about ,000 students in 1960) as the primary factor, increased from 5,722 to 22,993, while Hastings, a large trading center for the rural area, has increased from 9,338 to 21,412. See Table VI-3 for population data. 5/

Future

An analysis of the employment situation and using a number of

Federal and State studies as guides, the population and employment projections as shown in Table VI-3 were determined.

Agriculture

While the importance of agriculture and its related activities to the economy of the area is expected to decrease, it should continue to be one of the primary sources of employment and income.

Technological advances and other changes will continue to occur within the agricultural economy so that larger farms will be operated by smaller agricultural labor forces. The farm labor force is projected to decrease to 19,000 in 2020 and 15,800 in 2070.

Mining

Mining activity in the study area is expected to be limited to the extraction of sand and gravel. Projected employment in this category is expected to be insignificant.

Manufacturing

The importance of manufacturing to the economy of the study area is expected to continue to increase in the future.

Employment in the manufacturing category is projected to increase to 10,600 in 2020 and 15,800 in 2070. Fabricated metals industries (including machinery, vehicle, transportation equipment and other durables) and the food and kindred products category are expected to have the largest increases. Refer to Table VI-4 for employment projections.

Population

Utilizing Federal and State studies [6,7] and analyzing the employment situation, the population in the Big Blue River study area was projected to increase to 272,000 in 2020 and 340,000 in 2070. The urban sector is projected to increase to 180,000 in 2020 and 248,000 in 2070, while the rural segment is projected to decrease to 92,000 by 2020 and to remain at essentially that level thereafter. See Table VI-5 for population projections. [6, 7, 8]

Table VI-1

The Number and Percent of the Labor Force
by Major Subdivisions

Big Blue River Basin Study Area

1950 - 1960[1/]

	1950		1960		
	Number	Percent of Labor Force	Number	Percent of Labor Force	Percent Increase 1950-60
Farm	35,948	37	25,212	26	-30
Mining	226	-	166	-	-17
Manufacturing	5,370	6	6,286	7	+17
TOTAL BASIC	41,544	43	31,664	33	-24
TOTAL SERVICE	54,036	56	60,794	64	+13
UMEMPLOYED	1,540	-	2,452	3	+59
TOTAL LABOR FORCE	97,120	100	94,910	100	- 2
Population	249,530		243,773		- 2

Table VI-2

Manufacturing Employment

Big Blue River Basin Study Area[1/]

1950 - 1960

	1950	1960
Manufacturing	5,370	6,286
Fabricated Metals, Machinery, Vehicles and Other Durables	2,245	2,148
Food and Kindred Products	1,581	1,779
Printing and Publishing	722	834
Other Manufacturing	822	1,525

Table VI-3

Population Data

Big Blue River Basin Study Area

1910 - 1960[5/]

	1910	1920	1930	1940	1950	1960
Urban	41,188	51,463	65,881	61,943	77,592	85,870
Rural	245,949	230,419	214,238	192,588	171,938	157,903
TOTAL	287,137	281,882	280,119	254,531	249,530	243,773

Table VI-4

Projected Employment of the Labor Force

Big Blue River Basin Study Area

2020 - 2070[6, 7, 8/]

	2020	2070
Farm	19,000	15,800
Mining	-	-
Manufacturing	10,600	15,800
TOTAL BASIC	29,600	31,600
TOTAL SERVICE	72,200	95,100
UNEMPLOYED	4,200	5,300
TOTAL LABOR FORCE	106,000	132,000

Table VI-5

Population Projections

Big Blue River Basin Study Area

2020 - 2070[6, 7, 8/]

	2020	2070
Urban	180,000	248,000
Rural	92,000	92,000
TOTAL	272,000	340,000

VII. WATER REQUIREMENTS - MUNICIPAL AND INDUSTRIAL

Present Water Use

Approximately 25,000,000 gallons per day (mgd) of water is pumped for municipal and industrial uses in the basin. It is estimated that another 40 million gallons is pumped daily for agricultural (excluding irrigation) and on farm domestic use and over 100 billion gallons or 307,476 acre-feet is consumptively used annually for irrigation.

Existing Sources of Water - Surface and Ground Water

Ground water is the major source of supply in the basin. Only one municipality draws water from a surface source. Marysville, Kansas pumps an average of .40 mgd of surface water from the Big Blue River.

Some declines in water levels will occur, of course, but with adequate exploration and development, properly managed supplies will continue to meet anticipated needs. Water supplies in direct competition with irrigation use will be affected to a limited extent depending upon their proximity to such irrigation. Higher production costs, resulting from declining water levels and reduced saturated thickness, will play a large part in stabilizing the expected increase in pumpage for irrigation.

The chemical quality of the ground water in the basin is generally good. Most of the water is rather hard and some supplies have excessive iron and manganese concentrations, but these will be acceptable after adequate treatment. Concentrations of nitrate (NO_3) in excess of 45 mg/l, are present in at least eight municipal supplies (Exhibit 2)

are noted. These concentrations exceed the recommended (limits not to be exceeded) 1962 Public Health Service Drinking Water Standards. Excessive concentration of nitrate may give rise to infantile methemoglobinemia. Nitrate in ground water may be attributed to organic pollution but further investigation of the behavior of nitrate in ground water will be required.

Future Municipal and Industrial Water Requir ients

The increase in municipal and industrial water requirements in the Big Blue River Basin during the study period is based on anticipated population growth and increased per capita water use occasioned by a higher standard of living, the continued development of water using devices for the home and water use rates characteristic of similar areas in other parts of the country.

Per capita water consumption in the basin averages 158 gallons per day at present. This is expected to increase to 180 gpcd in 2020 and to 200 gpcd in 2070.

Based on the above, it is expected that the municipal and industrial water requirement will be 43 mgd in 2020 and 66 mgd in 2070. These figures include residential, commercial, public and industrial uses.

It is expected that ground water will continue to supply municipal and industrial water needs in the basin. The advantages of availibility and its desirable properties such as clarity, bacterial purity, and consistant temperature and chemical quality have led to its wide use.

VIII. WATER QUALITY CONTROL

Municipal, Industrial and Agricultural Pollution

Data on municipal and industrial waste discharges presented in the Public Health Service Municipal Waste Inventory is provided by the Kansas State Department of Health and the Nebraska State Department of Health. These data are presented in Exhibit 3 of the appendix.

The points of municipal waste discharge are shown on Figure VIII-5. Significant amounts of wastes are discharged at the following points: Beatrice, Crete, Fairbury, Hastings, Seward and York, Nebraska and at Marysville, Kansas. Secondary treatment of wastes is employed at the towns listed with the exception of Marysville, Kansas, Fairbury and York Nebraska, which have primary treatment.

Sufficient data are not available to quantify agricultural pollution in the form of runoff from fields and feed lots and pollution by pesticides.

Efforts were made, however, to quantify effects of irrigation return flow from the proposed Bureau of Reclamation's projects.

Water Quality Objectives

Water quality control needs are based on uses to which a stream may be put. Contaminated water can endanger the health of persons living near or coming in contact with the streams and unattractive water can reduce the aesthetic enjoyment of living in the vicinity of streams, rivers and lakes. Failure to meet the objectives at too frequent intervals can prevent the best use of a stream.

The objectives used in evaluating quality conditions in the Big

Blue River Basin are based on considerations of the objectives of Nebraska and Kansas, of various interstate agencies, and those that have been used by the Public Health Service in the past in similar situations.

As available data indicates that the mineral quality of the surface waters in the basin meets the U.S. Public Health Service 1962 Drinking Water Standards, and as it is expected that there will be no mineral pollution from irrigation return flow, quality control needs are based on the effect of organic material on the stream. The effect of organic waste discharge and the hydraulic characteristics of individual streams is reflected in the dissolved oxygen level. Maintenance of some dissolved oxygen is essential to prevent nuisance conditions. Concentrations of at least 3-5 mg/l are necessary to maintain fish and other aquatic life associated with desirable recreational use of a stream.

A dissolved oxygen objective of at least 5 mg/l has been selected in this study for the surface waters in the Big Blue River Basin to maintain the health aspects, fish and aquatic life and to maintain and enhance present and anticipated recreational use of the stream.

Flow Regulation

The Federal Water Pollution Control Act (Public Law 84-660 as amended by P.L. 87-88), provides that consideration must be given in the survey as planning of a reservoir by a Federal Agency to the inclusion of storage for regulation of streamflow for the purpose of

controlling water quality. The law also states that such storage and water releases shall not be provided as a substitute for adequate treatment or other methods of controlling waste at their source. For domestic wastes, it is considered possible to obtain 85 to 90 percent removal of BOD with well operated secondary waste treatment plants.

A BOD removal of 85 percent was considered reasonable for this project. Municipal and industrial flows of 70 percent of the water intake in the summer months, 75 percent in the spring and fall and 88 percent in the winter months containing 0.25 pounds of ultimate first stage BOD per capita have been used for purposes of estimating dilution requirements.

Discharge of wastes, even where treated to the maximum extent technically and economically feasible, will cause an unsatisfactory condition in waters whose waste assimilation capacity is exceeded.

Streamflows necessary to assimilate the anticipated municipal waste treatment plant effluents have been estimated on a seasonal basis for the waste loads anticipated in 1970, 2020 and 2070. In these estimates the water temperature for summer (June, July, August and September) averaged 25° C, fall (October, November) 12° C, winter (December, January, February, March) 0° C and spring (April, May) 15° C.

The available streamflow is considered adequate to assimilate wastes at Beatrice, Crete, Fairbury, Seward and Marysville.

At York, Nebraska, streamflow will need to be supplemented by streamflow regulation. The minimum streamflow needed for quality

control in the year 1970 is anticipated to be 12.1 mgd in the summer, 4.4 mgd in the spring and fall and 1.3 mgd in the winter. In the years 2020 and 2070, the minimum streamflow needs are anticipated to be 17.4 mgd, 6.8 mgd and 2.0 mgd and 23.7 mgd, 7.6 mgd, and 3.0 mgd, respectively for summer, winter and fall months.

Considering the need for water quality control, provision for storage to assure that flows are met 90 percent of the years is considered desirable. Since it is not always possible to control releases exactly and runoff from uncontrolled areas may exceed needs for short intervals of time, the estimated draft on storage needed has increased 10 percent. Actual releases should be based on observation of water quantity and quality; taking into account temperature, wastes actually reaching the stream, the quantity of water available in storage at the time, and anticipated rainfall.

An annual draft on storage* of 7,750 acre-feet to maintain 5 mg/l will be needed below York to supplement natural flows by the year 2070 for the selected dissolved oxygen quality objective of 5 mg/l.

At Hastings, Nebraska, there is a present total need for a minimum streamflow of 16 mgd in the summer, 11 mgd in the spring and fall, and 7 mgd in the winter. By the year 2070, an annual draft on storage* of 35,000 acre-feet will be required. No dilution water is available and as Hastings is on the extreme upper portion of the headwaters, none can feasibly be supplied.

*Annual draft on storage is defined as the sum of the incremental excesses of needed flows less the naturally available flow during a climatic year, (April-March).

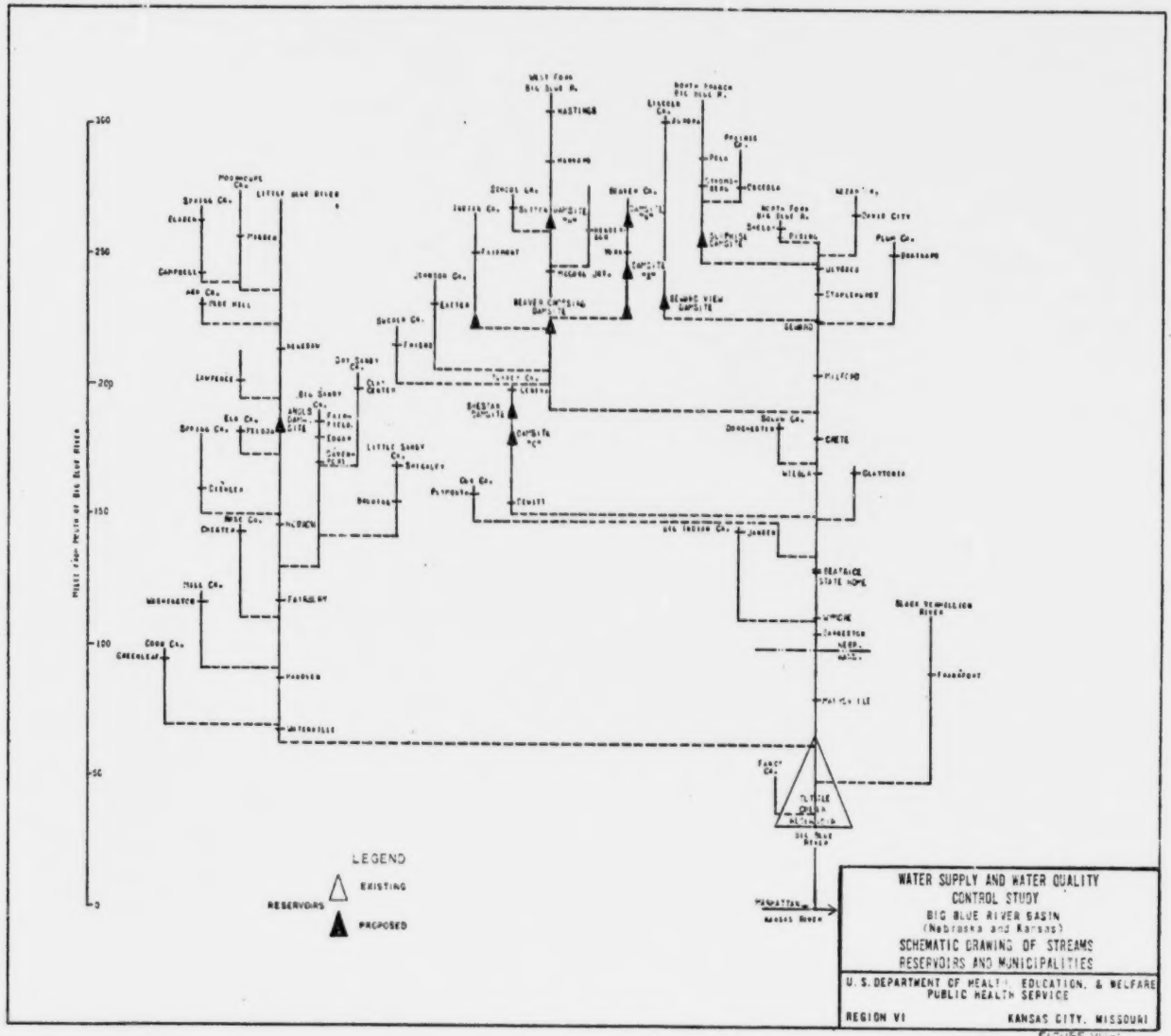
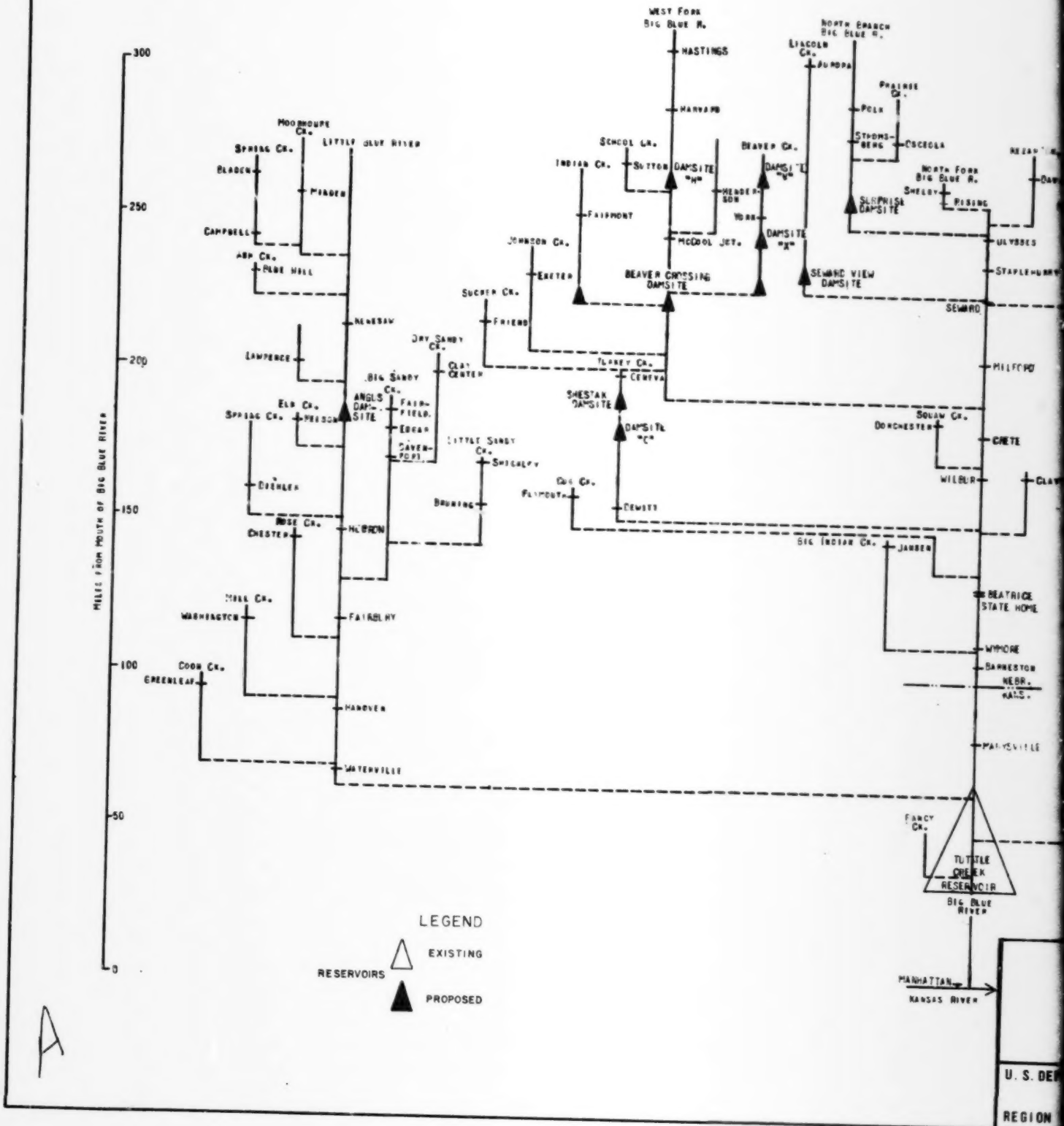


FIGURE VIII-1


MILES FROM MOUTH OF BIG BLUE RIVER
300
250
200
150
100
50
0
WEST FORK BIG BLUE R.
HASTINGS
HARVARD
SUTTON DAMSITE "H"
HENDERSON
FAIRMONT
McCOOL JCT.
DAMSITE "X"
BEAVER CROSSING DAMSITE
NORTH BRANCH BIG BLUE R.
LINCOLN CR.
SUMNER
PRAIRIE CR.
POLK
STROMSBERG
OSCEOLA
SCHOOL CR.
INDIAN CR.
BEAVER CR.
DAMSITE "Y"
SURPRISE DAMSITE
NORTH FORK BIG BLUE R.
SHELBY
RISING
YORK
ULYSSES
STAPLEHURST
SEWARD
SEWARD VIEW DAMSITE
JOHNSON CR.
EXETER
SUCKER CR.
FRIEND
TURKEY CR.
CERESCO
SHESTAK DAMSITE
DAMSITE "C"
DEWITT
MILFORD
SOLAR CR.
DORCHESTER
CRETE
WILBER
CLAY
BIG INDIAN CR.
JANSEN
BEATRICE STATE HOME
WYMORE
BARNESTON
NEBR.
KANS.
MARYSVILLE
FANCY CR.
TUTTLE CREEK RESERVOIR
BIG BLUE RIVER
MANHATTAN
KANSAS RIVER
MOORHOUSE CR.
SPRAGG CR.
LITTLE BLUE RIVER
BLADEN
MEADEN
CAMPBELL
ABP CR.
BLUE HILL
NEWBURY
LAWRENCE
DRY SANDY CR.
CLAY CENTER
BIG SANDY CR.
ANGLS DAMSITE
FAIRFIELD
EDGAR
CARVER-POLK
ELK CR.
PRESCOTT
SPRAGG CR.
DEEHLER
ROSE CR.
CHESTER
HEBRON
LITTLE SANDY CR.
SHICKLEY
BRUNING
OAK CR.
FAIRMONT
MILL CR.
WASHINGTON
FAIRBURY
COON CR.
GREENLEAF
HANOVER
WATERVILLE
LEGEND
RESERVOIRS
EXISTING
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A
U. S. DE
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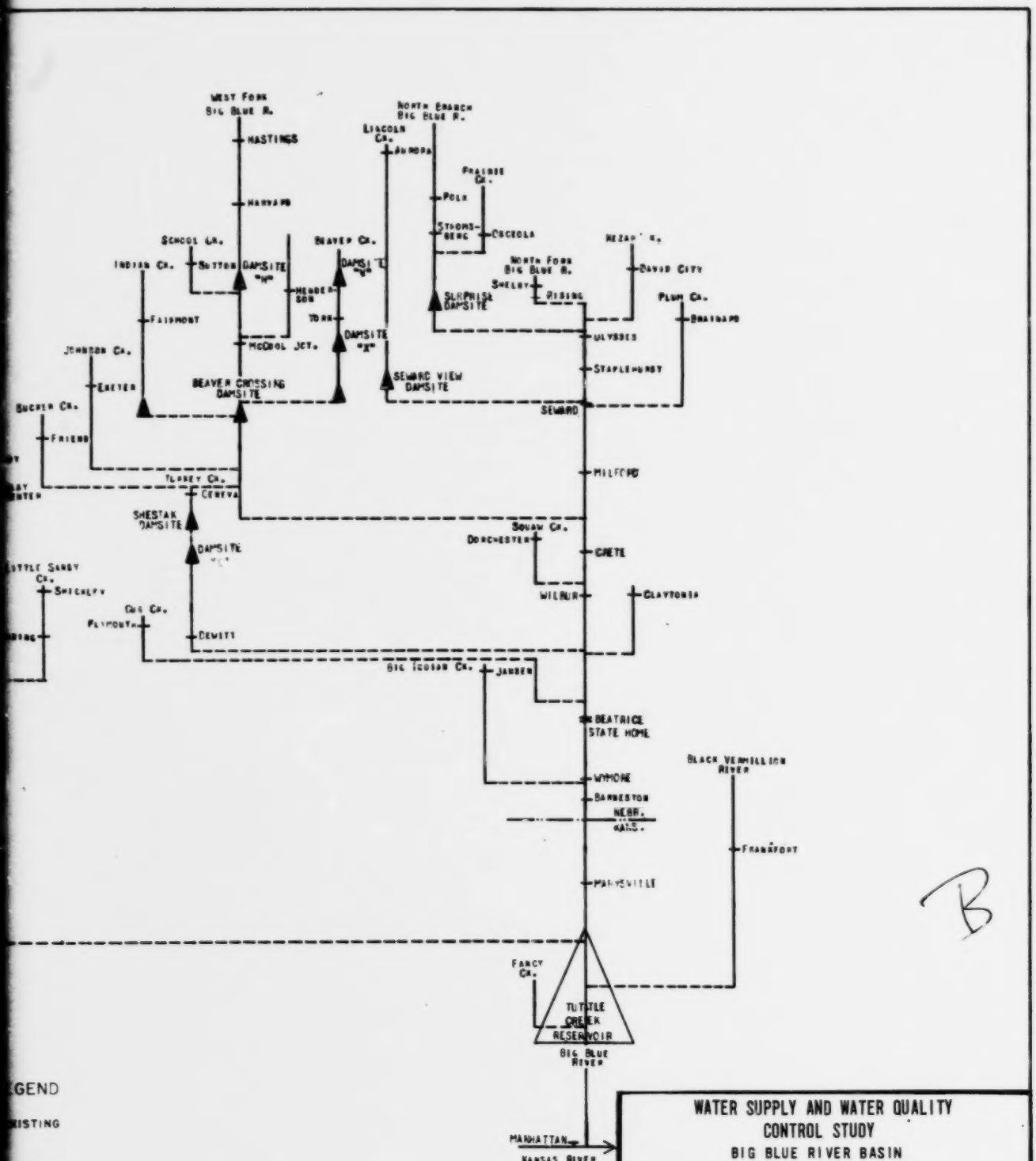

EGEND

XISTING

ROPOSED

WATER SUPPLY AND WATER QUALITY CONTROL STUDY

BIG BLUE RIVER BASIN
(Nebraska and Kansas)

SCHEMATIC DRAWING OF STREAMS RESERVOIRS AND MUNICIPALITIES

U. S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE

REGION VI KANSAS CITY, MISSOURI

FIGURE VIII-1

IX. BENEFITS

Water Supply - Municipal and Industrial

It has been determined that on the basis of available data, existing sources of water will be sufficient to meet the anticipated future demands of the communities of the study area for municipal and industrial purposes.

Water Quality Control

Benefits attributable to storage for streamflow regulation for water quality control may or may not have a measurable dollar value. Benefits can be provided from the recreational use of the stream and improved esthetics of the stream stemming from clean surface waters.

Water quality control management by the proposed reservoir above York in the Big Blue River Basin will provide benefits from recreational use of approximately 270 river miles of the stream from the damsite to Tuttle Creek Reservoir. Assured water quality will provide more favorable conditions for recreation such as swimming, water skiing, boating and fishing with a safe public health environment and the absence of noxious odors, floating solids and excessive turbidity. The total population of the study area is estimated to be 340,000 by 2070. It is not unreasonable to anticipate that a large portion of the total population in the study area, plus many of the people located in the Lincoln SMSA will be able to enjoy the recreational opportunities offered.

The Big Blue River and its main tributaries now represent some of the better catfishing streams in Nebraska and Kansas and support

heavy fishing pressure. The river system is noted for its fine catches of flathead catfish, channel catfish and bullheads.

With provisions for streamflow regulation, it is expected that the 270 mile reach of stream below the damsite will support an estimated 150,000 fisherman-days annually by 1970, increasing to 250,000 fisherman-days by 2070. The reservoir will support approximately 20,000 fisherman-days annually, increasing to about 50,000 fisherman-days by 2070. These estimates are based on preliminary estimates by the Fish and Wildlife Service and should be refined when additional information is available.

In addition to recreational benefits, riparian property owners will enjoy improved esthetics of the stream stemming from clean surface water.

From the above, it is concluded that benefits are widespread and general in nature, and warrant the provision of storage for the required streamflow regulation. These benefits will not be realized in the absence of adequate treatment of wastes or other methods of controlling wastes at the source.

In the absence of adequate means of evaluating directly the economic effects of water quality control, the cost of achieving the same results by the most likely alternative has been used to approximate the minimum value of benefits anticipated. After considering various methods of providing the required water quality control, it is concluded that a single purpose reservoir at the project site capable of providing an annual draft on storage of

7,750 acre-feet in 9 years out of 10 is considered worth $190,400 per year including operation and maintenance. This is based on a capital cost of $5,500,000 amortized at a rate of 3 1/8 percent for 100 years and includes $10,000 per year for operation and maintenance. Since there is an immediate need, benefits have not been discounted.

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APPENDIX

Exhibit No. 1

Municipal Water Supplies

Big Blue River Basin Study (Nebraska and Kansas)

Municipality	1960 Population	Estimated Population Served (1962)	Water Treatment	Source of Supply	Est. Max. Dependable Draft (mgd)	Average Output (mgd)	GPCD
NEBRASKA							
Alexandria	257	235	None	1 Well	.216	.019	80
Aurora	2,756	2,600	None	3 Wells	2.400	.500	192
Axtell	477	520	None	2 Wells	.360	.080	154
Beatrice	12,132	12,250	None	4 Wells	3.900	2.000	163
Beaver Crossing	439	450	None	1 Well	.360	.045	100
Belvidere	185	180	None	1 Well	.210	.030	143
Benedict	170	165	None	2 Wells	.140	.015	90
Bladen	322	335	None	1 Well	-	.020	60
Blue Hill	723	730	None	4 Wells	.570	.056	80
Blue Springs	509	500	None	Wymore			
Bradshaw	306	305	None	2 Wells	.238	.025	80
Brainard	300	300	None	3 Wells	.198	.027	90
Bruning	289	345	None	2 Wells	.575	.040	116
Campbell	424	430	None	2 Wells	.500	.035	80
Carleton	207	200	None	2 Wells	.216	.035	175
Chester	480	460	None	2 Wells	.650	.068	148
Clatonia	203	205	None	1 Well	.144	.016	80
Clay Center	792	780	None	3 Wells	1.440	.060	80
Cortland	285	285	None	2 Wells	.100	.031	109
Crete	3,546	3,500	None	4 Wells	2.160	.400	114

Exhibit No. 1 (cont'd.)

Municipal Water Supplies

Big Blue River Basin Study (Nebraska and Kansas)

Municipality	1960 Population	Estimated Population Served (1962)	Water Treatment	Source of Supply	Est. Max. Dependable Draft (mgd)	Average Output (mgd)	GPCD
NEBRASKA (cont'd.)							
Davenport	416	400	None	4 Wells	1.300	.036	90
David City	2,304	2,900	None	4 Wells	1.500	.375	130
Deshler	956	950	None	3 Wells	.650	.090	95
De Witt	504	500	None	2 Wells	.350	.082	164
Diller	286	275	None	3 Wells	.140	.024	80
Doniphan	390	390	None	2 Wells	.130	.050	128
Dorchester	460	460	None	2 Wells	.650	.055	120
Dwight	209	205	None	1 Well	.216	.030	146
Edgar	730	730	None	3 Wells	.750	.200	274
Endicott	-	-	-	-	-	-	-
Exeter	745	745	None	3 Wells	.550	.090	121
Fairbury	5,572	5,560	Chlorination, Fluoridation	4 Wells Spring Gallery	2.240	.900	162
Fairfield	495	490	None	2 Wells	.088	.050	101
Fairmount	829	835	None	2 Wells	.430	.085	102
Friend	1,069	1,060	None	2 Wells	.650	.240	226
Geneva	2,352	2,460	None	4 Wells	2.300	.120	49
Giltner	293	295	None	2 Wells	.430	.024	80
Glenville	323	325	None	2 Wells	0.625	.025	77
Grafton	171	175	None	1 Well	.250	.010	57

Exhibit No. 1 (cont'd.)

Municipal Water Supplies

Big Blue River Basin Study (Nebraska and Kansas)

Municipality	1960 Population	Estimated Population Served (1962)	Water Treatment	Source of Supply	Est. Max. Dependable Draft (mgd)	Average Output (mgd)	GPCD
NEBRASKA (cont'd.)							
Gresham	239	235	None	1 Well	.720	.038	162
Hebron	1,920	1,910	None	3 Wells	.650	.200	105
Hampton	331	335	None	2 Wells	.360	.024	80
Harvard	1,261	1,420	None	5 Wells	1.200	.140	100
Hastings	21,412	21,500	None	12 Wells	17.300	7.000	326
Henderson	730	750	None	2 Wells	.288	.075	100
Hubbell	126	120	None	2 Wells	.144	.015	125
Jansen	204	200	None	2 Wells	.032	.020	100
Juanita	422	430	None	1 Well	.144	.035	80
Kenesaw	546	535	None	2 Wells	.650	.042	80
Lawrence	338	335	None	5 Wells	.100	.015	45
Liberty	174	170	None	2 Wells	.043	.018	106
Marquette	210	210	None	2 Wells	.430	.015	75
Milford	1,462	1,630	None	6 Wells	.504	.165	100
Milligan	323	320	None	2 Wells	.165	.060	187
Minden	2,383	2,390	None	5 Wells	3.740	.329	158
Nelson	695	660	None	2 Wells	.230	.100	152
Odell	358	350	None	2 Wells	.085	.030	86
Ohiowa	195	190	None	2 Wells	.015	.016	80

Exhibit No. 1 (cont'd.)

Municipal Water Supplies

Big Blue River Basin Study (Nebraska and Kansas)

Municipality	1960 Population	Estimated Population Served (1962)	Water Treatment	Source of Supply	Est. Max. Dependable Draft (mgd)	Average Output (mgd)	GPCD
NEBRASKA (cont'd.)							
Osceola	1,013	900	None	2 Wells	.667	.090	100
Phillips	192	190	None	2 Wells	.288	.040	210
Plymouth	372	400	None	3 Wells	.460	.040	100
Polk	433	420	None	2 Wells	.283	.040	100
Reynolds	131	125	None	1 Well	.144	.015	120
Rising City	308	285	None	2 Wells	.230	.030	100
Ruskin	203	200	None	2 Wells	.792	.016	80
Seward	4,208	4,500	None	7 Wells	2.290	.587	130
Shelby	613	610	None	2 Wells	.360	.138	226
Shickley	371	385	None	2 Wells	.288	.075	195
Staplehurst	240	245	None	1 Well	.140	.020	80
Steele City	173	100	None	1 Well	.040	.005	50
Stromsburg	1,244	1,250	Iron Removal	2 Wells	.720	.125	100
Sutton	1,252	1,220	None	2 Wells	.866	.165	135
Swanton	190	185	None	1 Well	.144	.014	75
Tobias	202	190	None	1 Well	.140	.014	75
Utica	564	570	None	4 Wells	1.152	.060	100
Ulysses	357	360	None	2 Wells	.331	.045	125
Waco	166	160	None	2 Wells	.072	.012	75
Western	351	300	None	2 Wells	.065	.049	163
Wilber	1,358	1,380	None	3 Wells	1.010	.157	114
Wymore	1,975	1,700	None	5 Wells	1.440	.174	102
York	6,173	6,170	None	6 Wells	2.880	.731	118

Exhibit No. 1 (cont'd.)

Municipal Water Supplies

Big Blue River Basin Study (Nebraska and Kansas)

Municipality	1960 Population	Estimated Population Served (1962)	Water Treatment	Source of Supply	Est. Max. Dependable Draft (mgd)	Average Output (mgd)	GPCD
KANSAS							
Axtell	493	530	Chlorination	3 Shallow Wells	-	.050	94
Barnes	247	245	Chlorination	2 Deep Wells	-	.020	82
Beattie	314	325	Chlorination	3 Shallow Wells	-	.010	29
Blue Rapids	1,426	1,525	Chlorination	2 Shallow Wells	-	.150	98
Centralia	527	530	Chlorination	5 Shallow Wells	-	.040	75
Circleville	151	150	Chlorination	2 Shallow Wells	-	.010	67
Delia	163	160	Chlorination	2 Shallow Wells	-	.010	63
Frankfort	1,106	1,100	Chlorination	2 Deep Wells	-	.100	90
Greenleaf	562	560	Chlorination	4 Shallow Wells	-	.060	109
Haddam	311	300	Chlorination	3 Shallow Wells	-	.030	100
Leonardville	378	375	Chlorination	4 Deep Wells	-	.020	53
Mahaska	160	160	Chlorination	2 Deep Wells	-	.020	125
Manhattan	22,993	21,500	Iron Removal, Softening, Chlorination, Fluoridation	Shallow Wells	-	3.040	142
Marysville	4,143	4,250	Chlorination, Filtration, Sedimentation	Big Blue River and Shallow Well	-	.400	94
Mayetta	218	200	Iron Removal, Chlorination	2 Shallow Wells	-	.010	50

Exhibit No. 1 (cont'd.)

Municipal Water Supplies

Big Blue River Basin Study (Nebraska and Kansas)

Municipality	1960 Population	Estimated Population Served (1962)	Water Treatment	Source of Supply	Est. Max. Dependable Draft (mgd)	Average Output (mgd)	GPCD
KANSAS (cont'd.)							
Morrowville	195	200	Chlorination	2 Shallow Wells	-	.024	120
Munden	177	175	Chlorination	Shallow Wells	-	.010	57
Narka	166	170	Chlorination	Deep Well	-	.010	59
Netawaka	224	175	Chlorination	Deep Well	-	.010	57
Oketo	128	130	Chlorination	2 Wells	-	.010	77
Randolph	150	150	Chlorination	Shallow Well	-	.010	65
Soldier	171	175	Chlorination	2 Shallow Wells	-	.010	57
Vermillion	265	260	Chlorination	Shallow Well	-	.020	77
Washington	1,506	1,470	Chlorination	3 Deep Wells	-	.250	170
Waterville	700	750	Chlorination	2 Shallow Wells	-	.050	67
Whiting	233	250	Chlorination	2 Shallow Wells	-	.013	40
TOTALS	134,911	134,380				21.214	158 ave.

Exhibit No. 2

Typical Chemical Analyses of Public Water Supplies
Results in Milligrams per Liter (mg/l)

Big Blue River Basin Study (Nebraska and Kansas)

Location	Total Dissolved Solids	Chloride (Cl)	Sulfate (SO_4)	Nitrate (NO_3)	Hardness (as $CaCO_3$)	Iron (Fe)	Source
NEBRASKA							
Alexandria	312	11	24	<45	108	<0.03	Ground water
Aurora	246	16	28	<45	188	<0.03	Ground water
Axtell	344	30	19	<45	182	0.06	Ground water
Beatrice	296	28	16	<45	260	0.05	Ground water
Beaver Crossing	414	17	26	<45	244	0.50	Ground water
Belvidere	150	10	8	<45	104	<0.03	Ground water
Benedict	482	13	20	<45	264	0.03	Ground water
Blue Hill	420	27	24	<45	300	<0.03	Ground water
Bradshaw	380	17	20	<45	216	<0.03	Ground water
Bruning	290	40	32	<45	188	<0.03	Ground water
Campbell	440	20	76	<45	308	<0.03	Ground water
Carleton	195	36	4	<45	132	0.38	Ground water
Chester	220	4	8	<45	124	<0.03	Ground water
Clay Center	380	22	52	<45	300	0.10	Ground water
Cortland	230	22	10	<45	264	<0.03	Ground water
Crete	490	16	40	<45	264	0.24	Ground water
Davenport	140	26	1	<45	102	0.12	Ground water
David City	466	7	60	<45	364	0.02	Ground water
Deshler	168	11	5	<45	104	0.03	Ground water
DeWitt	520	282	53	23	260	0.10	Ground water
Diller	344	42	56	36	248	0.20	Ground water
Doniphan	526	13	140	<45	290	1.20	Ground water
Dorchester	328	16	40	<45	228	1.80	Ground water
Dwight	340	17	32	<45	296	1.51	Ground water
Edgar	298	36	16	<45	198	0.13	Ground water

Exhibit No. 2 (Continued)

Typical Chemical Analyses of Public Water Supplies
Results in Milligrams per Liter (mg/l)

Big Blue River Basin Study (Nebraska and Kansas)

Location	Total Dissolved Solids	Chloride (Cl)	Sulfate (SO_4)	Nitrate (NO_3)	Hardness (as $CaCO_3$)	Iron (Fe)	Source
NEBRASKA (Con'd)							
Exeter	9..	18	95	15	346	0.07	Ground water
Fairbury	420	78	20	9	208	<0.03	Ground water
Fairmount	412	22	28	<45	228	0.09	Ground water
Fairfield	250	24	8	<45	180	<0.03	Ground water
Friend	278	13	67	<45	276	<0.03	Ground water
Geneva	324	17	52	3.6	240	0.26	Ground water
Giltner	462	16	121	<45	278	0.07	Ground water
Glenville	200	20	4	<45	152	<0.03	Ground water
Grafton	230	20	28	<45	224	0.06	Ground water
Gresham	250	10	0	<45	268	<0.03	Ground water
Hampton	366	16	16	<45	204	0.36	Ground water
Harvard	282	20	106	<45	276	<0.03	Ground water
Hastings	250	12	28	<45	192	<0.03	Ground water
Hebron	232	12	8	6	156	<0.03	Ground water
Henderson	228	20	28	<45	208	0.09	Ground water
Hubbell	1,020	22	158	<45	364	0.02	Ground water
Jansen	418	36	22	<45	294	<0.03	Ground water
Juanita	122	22	0.01	<45	100	<0.03	Ground water
Kanesaw	162	33	0.12	<45	128	<0.03	Ground water
Lawrence	420	33	36	<45	248	0.06	Ground water
Marquette	378	13	148	<45	340	0.00	Ground water
Milford	498	15	30	<45	188	<0.03	Ground water
Milligan	624	22	148	<45	284	0.08	Ground water
Minden	388	14	66	<45	260	0.20	Ground water
Nelson	454	39	20	<45	288	<0.03	Ground water

Exhibit No. 2 (2)

Exhibit No. 2 (Continued)

Typical Chemical Analyses of Public Water Supplies
Results in Milligrams per Liter (mg/l)

Big Blue River Basin Study (Nebraska and Kansas)

Location	Total Dissolved Solids	Chloride (Cl)	Sulfate (SO_4)	Nitrate (NO_3)	Hardness (as $CaCO_3$)	Iron (Fe)	Source
NEBRASKA (Con'd)							
Odell	1,640	36	780	<45	816	<0.03	Ground water
Ohiowa	578	17	96	<45	412	<0.03	Ground water
Osceola	530	10	48	<45	356	<0.03	Ground water
Phillips	438	22	154	.18	288	<0.03	Ground water
Plymouth	802	100	174	58	452	<0.03	Ground water
Polk	314	18	20	<45	314	<0.03	Ground water
Reynolds	450	15	12	<45	280	<0.03	Ground water
Rising City	950	27	156	75	490	0.10	Ground water
Ruskin	450	48	24	<45	304	<0.03	Ground water
Seward	318	10	48	<45	148	<0.03	Ground water
Shelby	530	8	10	<45	348	0.06	Ground water
Shickley	312	32	18	<45	172	0.14	Ground water
Staplehurst	550	21	20	<45	256	<0.03	Ground water
Stromsburg	432	19	104	12.6	314	0.26	Ground water
Sutton	396	27	38	<45	230	0.75	Ground water
Swanton	346	31	56	<45	224	<0.03	Ground water
Tobias	740	46	172	<45	464	<0.03	Ground water
Ulysses	430	7	8	<45	204	<0.03	Ground water
Utica	228	12	16	<45	212	<0.03	Ground water
Waco	358	20	80	<45	316	<0.03	Ground water
Western	442	37	24	<45	318	<0.03	Ground water
Wilber	324	34	30	7.2	168	0.24	Ground water
Wymore	325	28	28	<45	248	<0.03	Ground water
York	344	12	27	9.5	264	0.55	Ground water

Exhibit No. 2 (continued)

Typical Chemical Analyses of Public Water Supplies
Results in Milligrams per Liter (mg/l)

Big Blue River Basin Study (Nebraska and Kansas)

Location	Total Dissolved Solids	Chloride (Cl)	Sulfate (SO_4)	Nitrate (NO_3)	Hardness (as $CaCO_3$)	Iron (Fe)	Source
KANSAS							
Axtell	618	56	66	80	440	0.07	Ground water
Barnes	583	46	42	49	460	0.09	Ground water
Beattie	1,169	61	539	8.0	700	0.28	Ground water
BlueRapids	481	11	100	13	414	0.09	Ground water
Centralia	838	53	270	2.8	554	8.8	Ground water
Circleville	1,728	35	948	0.8	1,182	0.27	Ground water
Delia	1,461	401	167	1.1	553	0.40	Ground water
Frankfort	353	12	38	3.9	261	0.05	Ground water
Greenleaf	508	18	118	30	355	0.09	Ground water
Haddam	427	27	41	53	294	0.09	Ground water
Leonardville	532	32	36	58	402	0.09	Ground water
Mahaska	899	189	141	0.4	94	0.45	Ground water
Manhattan	337	68	88	1.2	137	0.03	Ground water
Marysville	379	43	59	1.6	242	0.04	Ground water & Big Blue River
Mayetta	481	25	67	1.6	416	0.18	Ground water
Morrowville	303	9.0	37	6.2	220	1.17	Ground water
Munden	708	63	104	71	470	0.01	Ground water
Narka	1,353	380	223	0.9	122	0.49	Ground water
Netawaka	---	240	105	0.8	318	0.15	Ground water
Oketo	648	27	79	43	530	0.01	Ground water
Randolph	1,550	41	851	2.0	1,154	0.0	Ground water
Soldier	1,360	61	691	14.0	962	0.0	Ground water
Vermillion	409	16	15	0.0	294	3.8	Ground water
Washington	210	8.0	30	2.3	112	0.04	Ground water
Waterville	511	21	60	19	437	0.00	Ground water
Whiting	372	17	48	12	294	0.10	Ground water

Exhibit No.3

Basic Data on Sources of Pollution

Big Blue River Basin Study (Nebraska and Kansas)

Municipality	River Miles Above Mouth	1960 Population	1963 Population Served	P.E.(BOD) Before Treatment	Nature of Waste	Treatment Provided	P.E. (BOD) Discharged	Water Course
NEBRASKA								
Aurora	299	2,576	2,000	2,000	Domestic	Lagoon	0	Lincoln Creek
Axtell	235E	477	470	470	Domestic	Secondary	120	Dry Run
Barneston	103	177	150	150	Domestic	Lagoon	0	Blue River
Beatrice	130	12,132	12,000	15,000	Domestic & Industrial	Secondary	3,500	Big Blue River
Beatrice State Home	130	2,185	2,185	1,700	Domestic	Secondary	170	Big Blue River
Beaver Crossing	277	439	300	300	Domestic	None	300	W.Fork Big Blue
Benedict	275E	170	150	150	Domestic	Lagoon	0	--
Bladen	262E	322	320	320	Domestic	Lagoon	0	Flat Creek
Blue Hill	231	723	600	600	Domestic	Secondary & Lagoon	150	Creek
Bradshaw	260E	306	300	300	Domestic	Lagoon	0	Land
Brainard	250	300	300	300	Domestic	Septic Tank	180E	Plum Creek
Bruning	155	289	150	150	Domestic	Secondary	25E	Dry Sandy Creek
Campbell	243	424	410	410	Domestic	Primary	280E	Little Blue R.
Chester	144	480	300	300	Domestic	Primary	75E	Rose Creek
Clatonia	167	203	190	150E	Domestic	Lagoon	0	Clatonia Creek
Clay Center	131	792	780	780	Domestic	Lagoon	0	Little Sandy Ck.
Crete	181	3,546	3,500	8,500E	Domestic & Industrial	Secondary	600	Big Blue River
Davenport	102	416	250	250	Domestic	Secondary	80E	Draw to Sandy Cr.
David City	267E	2,304	2,300	2,300	Domestic	Lagoon	0	Keysor Creek
Deshler	161	956	950	950	Domestic	Secondary	300E	Spring Creek
De Witt	155	504	400	400	Domestic	Primary	240E	Turkey Creek
Diller	150E	286	275	275	Domestic	Lagoon	0	--

Exhibit No. 3 (Continued)

Basic Data on Sources of Pollution

Big Blue River Basin Study (Nebraska and Kansas

Municipality	River Miles Above Mouth	1960 Population	1963 Population Served	P.E.(BOD) Before Treatment	Nature of Waste	Treatment Provided	P.E. (BOD) Discharged	Water Course
Doniphan	300E	390	380	380	Domestic	Secondary & Lagoon	0	Lagoon
Dorchester	189	460	450	450	Domestic	Secondary	150E	Squaw Creek
Edgar	180	730	720	720	Domestic	Secondary	200E	Sandy Creek
Exeter	229	745	600	600	Domestic	Secondary	150E	Johnson Creek
Fairbury	117	5,572	5,550	6,000	Domestic & Industrial	Primary	4,000E	Little Blue R.
Fairfield	126	495	490	490	Domestic	Secondary	110E	Roadside ditch to Big Sandy Ck.
Fairmont	250	829	800	800	Domestic	Secondary	120	Ditch to Indian C.
Friend	215E	1,069	1,000	1,000	Domestic	Secondary	200E	Sucher Creek
Geneva	204	2,352	2,300	2,300	Domestic	Secondary	900E	N.Br.Turkey Cr.
Giltner	290E	293	290	290	Domestic	Lagoon	0	Land
Glenville		323	300	300	Domestic	Lagoon	0	Lagoon
Grafton	250E	171	150	150	Domestic	Lagoon	0	--
Gresham	250E	239	220	230	Domestic & Industrial	Lagoon	0	Land
Hampton	280E	331	320	320	Domestic	Lagoon	0	Land
Harvard	259	1,261	900	900	Domestic	Secondary	250E	Br.to W.Fk.Blue R.
Hastings	233	21,412	21,000	25,500	Domestic & Industrial	Secondary	6,600E	W.Fk.Blue River
Hebron	152	1,920	1,900	1,900	Domestic	Primary	1,200E	Little Blue R.
Henderson	259	730	720	720	Domestic	Secondary	140E	Ck.to W.Fk.B.Blue
Jansen	145	204	160	160	Domestic	Secondary	30E	Big Indian Ck.
Juanita	240E	422	400	400	Domestic	Lagoon	0	Land
Kenesaw	214	546	250	250	Domestic	Secondary	60E	32 Mile Creek
Lawrence	202	338	220	200	Domestic	Secondary	45E	Common Creek
McCool Jct.	242E	246	240	240	Domestic	Lagoon	0	W.Fk.Big Blue R.
Marquette	280E	210	200	200	Domestic	Lagoon	0	--

Exhibit No. 3 (Continued)

Basic Data on Sources of Pollution

Big Blue River Basin Study (Nebraska and Kansas)

Municipality	River Miles Above Mouth	1960 Population	1963 Population Served	P.E.(BOD) Before Treatment	Nature of Waste	Treatment Provided	P.E. (BOD) Discharged	Water Course
Milford	204	1,462	1 350	1,350	Domestic	Primary	800E	Big Blue River
Milligan	210E	323	300	300	Domestic	Lagoon	0	--
Minden	257	2,383	2,000	2,000	Domestic	Secondary & Lagoon	500E	Sand Creek
Nelson	187	695	670	670	Domestic	Lagoon	0	Elk Creek
Osceola	275	1,013	950	950	Domestic	Lagoon	40	Prairie Creek
Plymouth	158E	372	350	350	Domestic	Lagoon	0	--
Polk	287	433	400	400	Domestic	Lagoon & Secondary	35E	Dry Creek
Rising City	265E	308	310	300	Domestic	Lagoon	0	N.Fork Big Blue
Ruskin	175E	203	175	175	Domestic	Lagoon	0	
Seward	225	4,208	4,000	4,000	Domestic	Secondary	400E	Big Blue River
Shelby	265	613	350	350	Domestic	Lagoons	0	Dry Creek
Shickley	168	371	150	150	Domestic	Secondary	40	Dry Sandy Creek
Staplehurst	236	240	225	225	Domestic	Primary	150E	Blue River
Stromsburg	277	1,244	1,250	1,250	Domestic	Secondary	320E	N.Br.Blue River
Sutton	266	1,252	1,200	1,200	Domestic	Secondary	200E	School Creek
Swanton	140E	190	150	150	Domestic	Lagoon	0	Swan Creek
Ulysses	246	357	300	300	Domestic	Lagoon	0	Big Blue River
Utica	250E	564	540	540	Domestic	Lagoon	25E	Land
Virginia	125E	88	80	80	Domestic	Lagoon	0	--
Waco	260E	166	130	130	Domestic	Primary	0	Land
Western	200E	351	435	435	Domestic	Secondary	65	Ditch to Creek
Wilber	167	1,358	1,300	1,300	Domestic	Secondary	500E	Big Blue
Wymore	111	1,975	1,900	1,900	Domestic	Secondary	600	Big Blue
York	246	6,173	6,000	30,000	Domestic & Industrial	Secondary	4,000E	Beaver Creek

Exhibit No. 3 (Continued)

Basic Data on Sources of Pollution

Big Blue River Basin Study (Nebraska and Kansas)

Municipality	River Miles Above Mouth	1960 Population	1963 Population Served	P.E.(BOD) Before Treatment	Nature of Waste	Treatment Provided	P.E. (BOD) Discharged	Water Course
KANSAS								
Axtell	88	562	500	500E	Domestic	Secondary	75E	Trib.to Black Vermillion River
Barnes	70E	247	-	-	--	--	-	--
Beattie	90E	364	-	-	Domestic	Stabilization Ponds	70E	Wolfe Creek
Blue Rapids	60	1,497	1,250	1,250E	Domestic	Primary	750E	Big Blue River
Frankfort	199	1,127	1,125	1,125E	Domestic	Primary	675E	Black Vermillion
Greenleaf	170	600	600	600E	Domestic	Secondary	90E	Dry Trib. of Coon Creek
Marysville	80	4,212	4,150	4,650	Domestic & Industrial	Primary	2,900E	Big Blue River
Washington	192	1,581	1,500	1,750	Domestic	Secondary	262E	Mill Creek
Waterville	145	774	700	700E	Domestic	Primary	420E	Little Blue R.

Exhibit No. 4

Historical Streamflows

Big Blue River Basin Study (Nebraska and Kansas)

Station	Location	Drainage Area (sq.mi.)	River Miles*	Years of Record	Flows in cfs		
					Maximum	Minimum	Average
Lincoln Creek near Seward, Nebraska	2½ miles upstream from mouth	420	228	9	10,100	1.3	45.8
Big Blue River at Seward, Nebraska	At Seward	1,070	225	9	15,300	0	98.0
W. Fork Big Blue near Dorchester, Nebraska	19 miles upstream from mouth	1,210	211	4	11,200	36	-
Big Blue River near Crete, Nebraska	At Crete, 3.6 miles upstream from Squaw Creek	2,680	181	18	27,600	13	341**
Turkey Creek near Wilber, Nebraska	3 miles S.W. of Wilber, 9 miles upstream from DeWitt	490	164	3	7,300	2.1	-
Little Blue River near Deweese, Nebraska	1 mile upstream from Walnut Creek	1,140	190	9	13,000	25.0	148
Little Blue River near Fairbury, Nebraska	5½ mi. upstream from Rose Ck., 3/4 mi. S. of Fairbury	2,320	117	41	36,800	14.0	370
Big Blue River at Barneston, Nebraska	2 mi. upstream from Plum Ck. 5 mi. upstream from St. Line	4,420	103	30	57,700	1.0	776
Little Blue River at Barnes, Kansas	0.4 mi. downstream from Malone Ck., 4.5 mi. N. of Barnes	3,330	68	5	38,800	76.0	720

Exhibit No. 4

Exhibit No. 4
(cont'd)
Historical Streamflows

Big Blue River Basin Study (Nebraska and Kansas)

Station	Location	Drainage Area (sq. mi.)	River Miles*	Years of Record	Flows in cfs		
					Maximum	Minimum	Average
Black Vermillion River near Frankfort, Kansas	2.2 mi. S.W. of Frankfort	412	60	10	38,300	0.0	125
Fancy Creek at Winkler, Kansas	0.4 mi. south of Winkler	176	40	9	19,200	0.0	42.3
***Big Blue River at Randolph, Kansas	3/4 mi. E. of Randolph	9,100	32	42	98,000	31	1,686
Big Blue River near Manhattan, Kansas	4 mi. N. of Manhattan, 7.3 mi. upstream from mouth	9,560	7	9	93,400	48	1,788

*River miles approximate.
**Average for period 1953-62.
***Discontinued